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MINERAL EXPLORATION IN THE WESTERN RIFT, TANGANYIKA

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MINERAL EXPLORATION IN THE WESTERN RIFT (TANGANYIKA)

J.H.G. Fuchter, Ph.D., A.M.I.M.M.

INTRODUCTION

1. Between 1956 and 1960 an extensive mineral exploration programme was carried out over an area of 34,000 square miles in the Western Rift in Tanganyika (See figure 1).

2. This area, situated in the Lake Rukwa-Lake Tanganyika region, is in one of the most remote and under-developed parts of Africa. Its topography is characteristic of an area which had been subject to rift faulting; mountainous in places with unrelieved plains elsewhere. Vegetation varies from swamp to open savannah and parkland, from dry to wet forests.

3. Herds of big game were frequently encountered in many parts of the concession area. Hazards to health, particularly malaria and sleeping sickness, had to be carefully watched. Communications were poor or non-existent.

4. The area was unfamiliar and largely unmapped and the geology little understood. Mineralization, most of it uneconomic, was known to exist and included gold, lead, copper and nickel.

5. The mineral exploration programme carried out in this area included the use of most of the modern prospecting techniques.

6. In the following pages the methods employed and some of the results obtained and also a few important aspects of organization, personnel selection and expenditure are discussed.

II. ORGANIZATION AND STAFF

7. Prospecting of the concession area of 34,000 square miles was completed in four-and-a-half years by a staff of eleven field geologists, eighteen field assistants, three senior geologists (including the geologist-in-charge), one mineralogist-petrologist, one photo-geologist, one geochemist, two geochemical laboratory assistants, two administrative assistants, one motor mechanic, one pilot and one driller, and an average labour force of five hundred. (See figure II for the staff organisation).

8. Having a field force of eleven geologists and eighteen field assistants working in one concession area and whose efforts entailed the collecting of 10,000 soil and stream sediment samples and 500 to 1,000 panned concentrates per month, required a rigid standardization in the method of working and the representation of results. It would otherwise have been impossible to correlate and synthesize all incoming information.

9. A well-organized and standardized numbering system for samples, sample lines, sample blocks and areas was introduced for the geochemical soil sampling programme. Ground geophysical surveys were tied to this system, while a similar system was used for stream sediment sampling. In tackling a mineral exploration programme over such a large area, due regard had to be given to the principle of having a well-equipped base within or very close to the area concerned for the following reasons :-

10. (a) It is of the utmost importance that geochemical samples, panned concentrates and rock samples for mineral identification reach the laboratories as quickly as possible and that results are plotted and returned to the field parties while they are still operative in the areas concerned.

(b) Proper technical and administrative control can be exercised.

(c) It gives the field staff the opportunity of visiting base periodically. This is advantageous from the point of view of compiling reports, preparing maps, discussing problems with colleagues and obtaining information generally. It also contributes towards maintaining morale and also gives the field men an opportunity to live for a short period in a more congenial environment - a welcome break from harsh field conditions.

11. The careful selection of field personnel is particularly important if they are to withstand the tiring physical conditions and boredom of repetitive routine field procedure. The integrity, perseverance and enthusiasm of the professional geologist can usually be relied on but the importance of conforming rigidly to field procedures and standards often escapes the field assistant.

III (a) GEOLOGICAL INVESTIGATIONS.

12. It was apparent, at the inception of the programme, that a geological map of the area was essential, even although such a map depicted geological features which were not fully identified.

(i) Photo-geological mapping.

13 To get an overall picture of the geology as quickly as possible, a photo-geological interpretation was combined with a field reconnaissance. By sampling the geology on the ground and comparing it with air photographs it is reasonable to assume that whole areas shown on the photographs as having similar features, such as surface weathering, vegetation and colour, are similar to the sample. Furthermore, air photographs exhibit structural features, such as lineations, folds and faults, which cannot be seen easily, if at all, on the ground.

14 The field reconnaissance was completed in five months. It then took about another eight months before all photographs of the area concerned were re-interpreted in the light of the field evidence. Final maps were then compiled.

15 The final product was a geological map on the scale of 1:50,000, which showed geological features with which the known mineralization could be correlated.

(ii) Regional mapping.

16 Subsequent geological work consisted of traversing areas on foot at suitable intervals. For example, an area shown by air photographs to be covered entirely by superficial deposits which obscured bedrock, could be traversed at intervals of one mile to determine, for example, whether variations in colour and texture of the cover would reveal something about the bedrock. On the other hand, an area of exposed bedrock of obvious economic

potential would be traversed at intervals of a quarter of a mile or less.

17. An area of other exposed rock, however, considered to be of little interest, would be mapped in conjunction with geochemical drainage reconnaissance sampling and panning of river gravels. Since sampling and panning were mostly done by field assistants, only a few selected widely spaced watercourses, preferably cutting across strike, were mapped.

18. In this way the photo-geological map was improved, resulting in a better understanding of the geological history. This in turn provided a better background for assessing the economic potentialities of the concession area.

(iii) Detailed mapping.

19. This type of geological work was restricted to areas of special interest and was usually undertaken in conjunction with detailed ground geophysical work over geochemical and airborne geophysical anomalies and also in areas of known mineralization. It usually consisted of traversing at intervals of 200 feet and was done mainly during the latter stages of the exploration programme. Approximately 0.2% of the total concession area was investigated in this way.

(b) Geochemical investigations.

20. Geochemical prospecting in the Western Rift entailed the collection of 290,000 samples, which in turn involved 1,350,000 individual geochemical tests. The laboratory was geared to undertake 80,000 tests per month.

(i) Drainage reconnaissance sampling.

21. Geological mapping in the Western Rift was expected to facilitate the delimitation of areas of possible mineralization potential. However, it was also fully realized that geological reasoning could be faulty and that economic mineralization might well be present in an area in which the geological evidence available at that time did not appear favourable.

22. It was therefore decided to sample the drainage of the entire concession area systamatically with the exception of the Recent lake sediments of the Rukwa Rift Valley. In this manner the distribution of base metal traces in the drainage could be mapped, with the object of delineating areas of interest for more detailed prospecting work.

23. A total of 90,000 stream sediment silt and mbuga (seasonal swamp) clay samples was collected at half mile intervals from the drainage courses. The samples were dried where necessary and then lightly ground and sieved through 80 mesh screens. The undersize fraction was despatched to the laboratory at base for analysis.

24 The samples were analysed by the following methods :-

a. The dithizone cold extraction method (detection limit ± 0.5 parts per million) for available copper and zinc.

b. By perchloric acid extraction and subsequent colorimetric analysis (detection limits 5 to 15 parts per million), for total copper, lead and nickel.

25. Analytical results in parts per million were plotted for each metal adjacent to each sample site on separate 1:50,000 scale location maps (DOS sheets, published by Directorate Overseas Services, London). An empirical set of values, based on the consideration of a large number of values from differing drainage types and geological environments, was chosen for each metal to define the background, threshold, possible and probable anomalous limits. The anomalous and threshold values were then contoured and transferred to separate maps (1:500,000) of the concession area.

26. These maps show the presence of well-defined anomaly patterns for nickel copper, lead and zinc. The high-order nickel anomalies appear to be related to ultrabasic intrusives and generally have coincident copper anomalies. Both cold extraction copper and zinc anomalies have a widespread distribution. Cold extraction copper confirms total copper anomalies in most cases, but the former is much more widespread. Many cold extraction copper anomalies are not supported by total copper.

27. Threshold and possible anomalous nickel and copper values are usually associated with mafic rock types.

28. In some cases higher values for one or two particular metals appear to be related to areas underlain by certain rock types. For example, higher total lead values are associated with the more widely distributed rhyolitic lavas, granite porphyries and granites. On the other hand, the occasional carbonatitic and associated alkaline rocks are outlined either by higher zinc values or by higher lead values.

29. It is of interest to note that, with two exceptions, high-order anomalies occur in areas which on geological grounds were considered to have greater mineralization potential than others.

30. The two exceptions were a copper and a nickel-copper anomaly in areas underlain by younger sediments. These were assumed to be of little importance from the economic point of view. Follow-up work on these anomalies established that they were not related to any form of mineralization.

31. One high-order copper-nickel anomaly was found to be related to mineralization which unfortunately appeared to be uneconomic.

(ii) Systematic soil sampling was limited to (a) areas of known mineralization, (b) areas which appeared to be economically favourable on geological grounds, and (c) areas in which anomalies were found by drainage reconnaissance sampling.

32. A total of two thousand square miles was sampled in this manner, involving the collection of 200,000 samples.

33. Selected areas were divided into blocks of 16,000 feet square. For this purpose base lines were cut on a 16,000 foot grid and accurately surveyed. Tie lines at right angles to the base lines were also cut and surveyed at 32,000 foot intervals. Both base lines and tie lines were blazed with red or yellow paint. Hardwood stakes were inserted along the base lines at 200 foot intervals. Base lines were plotted on air photographs and on 1:50,000 location maps (DOS sheets). Sampling was done along lines 2,000 feet apart at right angles to the base line with a sample station interval of 200 feet. Individual sample lines within one block were run by compass and also blazed with paint and numbered 0, 2, 4, 6, 8, 10, 12, 14, prefixed by the block number. Samples were taken at a depth of 18 inches and were consecutively numbered from 0 - 30 along each line (in the same direction throughout one area). Samples from one line were put in one box which carried the number of the DOS location sheet within which the sampled block occurred, the block number and the line number. This information was also written on the sample packets, together with the relevant sample number.

34. It will be appreciated that the sampling direction was dependent on mineralized (if known) or favourably considered geological and structural trends.

35. The layout of a systematic soil sampling grid was supervised by a geologist but carried out by two or more field assistants who, together with labourers, collected the samples, noting the type of soil, vegetation, topography and the absence or presence of rock outcrops. Geologists generally only mapped lines where outcrops occurred.

36. Samples were assayed by the same methods mentioned in paragraph 34 above.

37. Analytical results were plotted on block maps on a scale of 1:10,000 for each 16,000 feet square block, by two plotters attached to the geochemical laboratory. Geological information and soil types were mapped on the same scale but on a different map. Plotted analytical results were contoured and main geochemical trends and anomalies were transferred to 1:50,000 maps. Maps showing soil types, geology and structural features were also compiled on a scale of 1:50,000.

38. Although known mineralization was generally clearly outlined in the Mpanda area by systematic soil sampling, failure to locate a sizeable lead anomaly 6 miles north-west of Mpanda Mine should be mentioned. This lead occurrence was found with the aid of a local guide. It consisted of a small hole containing some galena float. Detailed soil sampling on a grid of 50 feet square established anomalous lead values of up to 6,000 parts per million over a distance of 500 feet. Subsequent pitting established the presence of weak lead mineralization in a northwest-southeast trending shear zone.

39. Systematic soil sampling had failed to establish the presence of this mineralized shear zone. Even fill-in sample lines at 1,000 foot intervals did not indicate the presence of this mineralization, which admittedly was uneconomic but could have been significant.

40. The reason for this failure was due to the fact that sample lines were in this case parallel to the mineralized trend. Systematic soil sampling should preferably be carried out along sample lines at right angles to each other, but this would increase costs considerably. Furthermore, the interval of 2,000 feet between sample lines might be too great and in some cases an interval of 1,000 feet would undoubtedly be warranted. The manner in which such a programme is conducted depends very largely on the judgement of the geologist-in-charge.

(iii) Detailed soil sampling was done over the following :-

a. Known mineralized occurrences in an attempt to find extensions.

b. Anomalies found by systematic soil sampling, in order to delimit them more accurately. This facilitated the siting of trenches, pits and boreholes.

c. Geophysical anomalies.

41. Sampling of this kind was usually done along sample lines at intervals of 200 feet with sample station intervals of 50 feet. However, in some cases such as described in paragraph 38, sampling would be carried out in much greater detail.

42. Sampling was also extended to bedrock. For this purpose pits with a diameter of 30 inches were dug down to bedrock, sometimes at a depth of 60 feet or more. These pits were sampled over lengths of 2 feet and results were plotted in vertical sections and contoured. Peak anomalies could be very accurately defined in this manner, thereby facilitating borehole location.

(c) Heavy mineral investigations.

43. This type of work consisted of the systematic collection of panned concentrates from stream gravels in conjunction with geochemical drainage reconnaissance sampling described in paragraphs 22 and 23.

44. Stream gravels or coarsest available stream sediments were sampled at intervals of one mile along all watercourses as part of the geochemical sampling programme. Samples weighing ten pounds each were collected or else panned on the spot if water was available. Concentrates were put in specially designed aluminium containers and sent to the mineralogical laboratory at base for identification.

45. By sampling the entire drainage system at intervals of one mile a sampling density of about one panning per square mile was attained.

46. Concentrates were examined microscopically by a mineralogist and the relative abundance of economically important minerals assessed by assigning them numbers, e.g. 1 for trace, 2 for present, 3 for abundant and 4 for predominant.

47. Each economic mineral also received a symbol, for example, W for tungsten-bearing minerals. The symbol and the relative abundance number were plotted adjacent to sample location on maps on a scale of 1:50,000 (DOS sheets).

48. In this way areas could be outlined where a relative concentration of economic important minerals occurred in panned gravels. Subsequent work consisted of closer sampling of watercourses in such areas to delimit areas of potential interest more accurately. In the third stage soils were panned on a closely spaced grid until the source of the mineral(s) was found.

49. Panning of stream sediments is a well-established, orthodox prospecting technique which can still be considered one of the most effective available to the exploration geologist. However, it also has its limitations. In large peneplained areas with mature, sluggish and senile drainage this method will lose much of its effectiveness in the search for sulphide minerals. Certain other minerals tend to slime easily and therefore cannot be traced very far from their source. It is nevertheless surprising that, even in peneplained regions, areas of relative interest can be outlined clearly by this method.

(d) Geophysical investigations.

(i) Airborne geophysical prospecting was extensively carried out in the Western Rift.

50. Ideally airborne geophysical maps should be available before systematic field work begins. However, it is obvious that they would be somewhat lacking in value due to the scanty geological evidence available in the initial stages of the programme. The value of such geophysical data will be enhanced with increased geological knowledge, thereby facilitating the selection of areas for intensive investigation.

51. The value of extensive airborne geophysical data lies not only in direct prospecting for magnetic bodies (for example, containing iron, nickel, platinoids or chromium) or conductive sulphides (such as those of nickel, copper and lead) or radioactive minerals, or as aids to mapping outcrops and structures, but in offering a challenge to the field geologist to explain the measurements, to re-examine his observations and interpretations and so to seek mineralization where otherwise he might have missed it.

52. The selection of areas for airborne geophysical examination was made on geological grounds and on evidence of probable mineralization. Such areas, totalling 10,000 square miles, were flown by a D.C. 3 aeroplane at 500 feet above ground level and on courses at intervals of a quarter of a mile across the regional geological trend. This aircraft was fitted with a scintillation counter, a proton free-precession magnetometer and electro-magnetic equipment, the receiver coil of which was placed in a "bird" connected to the aircraft by a cable 500 feet in length. The magnetometer was carried at the end of a stinger projecting from the tail of the aircraft. Results were compiled and plotted on maps on a scale of 1:50,000.

53. Magnetic maps were found to be very useful. Basic, ultrabasic and carbonatite bodies were clearly outlined. Structural trends showed up well and facilitated geological interpretation.

54. Results of the scintillation counter survey were disappointing, as soil cover (even where only a few inches thick) had a masking effect which tended to control the appearance of the plotted radiometric results. In consequence, little importance was attached to the radiometric maps. However, carbonatites appeared to be associated with well-defined anomalies whereas weak anomalies usually reflected the presence of granitoid outcrops.

55. The electro-magnetic survey measured the quadrature component at frequencies of 400 and 3,100 cycles per second. The quadrature component at 400 cycles per second was plotted when anomalous, whereas the ratios between that and the quadrature component at 3,100 cycles per second were listed.

56. The results were disappointing as far too many anomalies were found. They were difficult to assess as no criteria could be established to distinguish those anomalies possibly related to mineralization from those caused by electrolytes in clays and swamps. Several of the more interesting airborne electro-magnetic anomalies were followed up by ground electro-magnetic surveys, which in all cases failed to confirm the presence of the airborne anomalies. Many factors may be the cause of these discrepancies, such as change in the position of the "bird" in relation to the aircraft, and/or to the presence of extensive clay soil cover and seasonal swamps, the hosts of conducting electrolytes. These conditions prevail over a great part of the African continent and it is felt that more research in airborne electro-magnetic surveying should be carried out before being used for prospecting large unknown areas. In this connection it might be interesting to experiment with different frequencies and other types of aircraft, capable of flying at considerably less than 500 feet above ground level.

(ii) Ground geophysical survey.

57. This type of survey was concentrated on (1) locating and checking of anomalies detected by airborne geophysics, (2) small areas which were considered to have potential as a result of geochemical work, and (3) known mineral occurrences in an attempt to find extensions. These surveys were done with torsion magnetometers and electro-magnetic equipment.

58. a. Magnetometer surveys were carried out mainly to locate anomalies detected by airborne magnetics. In a few cases this technique was also used in an attempt to find a magnetic trend which could possibly be associated with a geochemical anomaly. Without exception airborne magnetic anomalies were confirmed by ground magnetometer surveying and this was of particular interest in areas lacking outcrops. All magnetic anomalies confirmed in this manner appeared to be associated with ultrabasic intrusives.

59. Ground magnetometer work done in conjunction with detailed geochemical surveying did not appear to be of much use. An association of geochemical and magnetic "highs" was rarely encountered and in the few cases where there was some form of agreement, it was not due to the presence of mineralization.

60. b. Ground electro-magnetic surveying was done over a number of airborne anomalies and in conjunction with detailed soil sampling and ground magnetometer surveys. A system of portable horizontal coils was used. Receiver and transmitter coils were 300 feet apart. A series of lightweight portable silver-zinc batteries served as a source of energy (12 volts). In-phase and quadrature components were measured at a frequency of 416 cycles per second at 50 foot intervals along lines - usually 200 feet apart - which coincided with the detailed soil sampling grid.

61. Results were plotted in parallel profiles. Significant anomalies were never detected, but this might be due to absence of sulphides in sufficient concentration. Anomalous trends were observed and in one case drilling established the presence of a graphite zone associated with such a trend

IV. CASE HISTORIES.

62. In the foregoing pages the various exploration techniques were discussed under separate headings. However, it should be stressed again that these techniques were closely integrated and often complementary. For example, geological interpretation benefited by the availability of magnetic maps, but on the other hand, interpretation of magnetic maps became much easier where the geology was better understood. In addition, geophysical results could only properly be assessed when sufficient geological information was known.

Two case histories illustrating the above will be described.

(a) Rungwa River area

63. In the initial stages of the exploration programme in the Western Rift, preliminary magnetic maps of the Rungwa River area (north-east of Lake Rukwa) showed the presence of a series of marked, parallel, north-south magnetic linears which looked interesting.

64. It was decided to send a field party to check the significance of the magnetic picture. For this purpose a track of 60 miles had to be made. On arrival, a site for an airstrip was selected and after six weeks the latter was being used. Geological mapping soon established that the magnetic linears

linears were related to vertical basic dikes. It was also found that these dikes were intrusive into a metamorphosed complex consisting of granitic gneisses and amphibolites. These metamorphosed rocks and the later intruded basic dikes were subsequently metasomatized, a process associated with a granitization front, involving the introduction of potash and silica. This geological picture appeared to be identical to that known to exist in a gold-copper-lead mineralized area 100 miles to the south-east (Lupa Gold Field). This justified a systematic soil sampling programme and a systematic examination of the heavy mineral contents of the various watercourses. Heavy mineral investigations established the widespread occurrence of traces of gold and scheelite. Systematic soil sampling did not outline high-order anomalies, but one lead anomaly was considered to be of more than passing interest. Detailed soil sampling combined with a ground electro-magnetic survey, heavy mineral investigations and subsequent pitting and trenching established the presence of secondary lead minerals in a sheared graphite-bearing pegmatitic zone.

65. Although this mineralization was uneconomic it demonstrated that the methods employed were capable of detecting even feeble mineralization.

(b) Kapalagula Area

66. Even in the earlier stages of the exploration in the Western Rift, the Kurigwe Bay area was considered to be of likely economic interest.

67. Nickel and copper sulphides were known to be present in the Kapalagula ultrabasic complex on the eastern shore of Lake Tanganyika. Previous exploration had shown this occurrence to be uneconomic, but it was known from a few scattered reconnaissance traverses that additional ultrabasic intrusives, potential host rocks for copper, nickel, chrome and platinoid mineralization, were present in the area. The very rugged topography precluded the use of airborne geophysical methods. Outcrops were scarce. A party of two geologists and two field assistants mapped the area on a regional scale and carried out a drainage reconnaissance sampling programme. The results of the latter clearly outlined a number of high-order nickel and copper anomalies, some of which were known to be associated with ultrabasic intrusives. One of the most striking anomalies was found south-east of Kapalagula in an area of no outcrop and this suggested a possible extension of the mineralized Kapalagula ultrabasic complex. The magnitude of the anomaly over the possible extension was considerably greater than over the mineralized Kapalagula intrusive itself. Subsequent systematic and detailed soil sampling combined with detailed geological mapping confirmed the presence of an extension of the Kapalagula ultrabasic intrusive. The soil sampling anomaly was well-defined and of a very high order. A ground electro-magnetic survey showed only a few vague anomalous trends which did not coincide with any geochemical anomalies. Pitting across geochemical peak anomalies down to a depth of 60 feet revealed the presence of geochemical values of 2 - 3% nickel and 2% copper in clays but only a few patches of disseminated pyrrhotite and chalcopyrite in weathered bedrock, which was uneconomic. Drilling did not establish the presence of any economic mineralization. The high values found during systematic soil sampling and subsequent detailed soil sampling and pitting are obviously the result of intensive and deep weathering which caused secondary enrichment of nickel in the clay soils. Although no ore bodies were found, the techniques employed helped to detect previously unknown mineralization.

V. EXPLORATION EXPENDITURE

68. Having attempted to describe an extensive mineral exploration programme in an unfamiliar and little known area, it might be of interest to mention the expenditure involved.

69 A total of £1,067,868 was spent, which can be detailed as follows:-

Administration Expenditure - Base	£	18,670
Administration Expenditure - Head Office		113,989
Labour		49,205
Aircraft		45,385
Camping Equipment		12,223
Drawing Office		9,767
Drilling		32,716
General		98,108
Geochemical Laboratory		36,449
Geophysical Survey		187,681
Housing and Maintenance		20,790
Mineralogical Laboratory		33,195
Photogeology		54,178
Radio Communications		2,143
Rental Concession Area		33,500
Track Building and Airstrips		14,216
Salaries (field personnel)		176,286
Travelling (field personnel)		7,269
Vehicle Maintenance		63,380
Loss of sale of Capital Equipment		58,718
	£	1,067,868

70. From these figures it can be seen that the geophysical work accounted for a substantial part of the total expenditure. Most of this was for airborne surveying - less than 5% was spent on ground surveying.

71. It is somewhat unfortunate that from the available figures no conclusion can be drawn about the costs of various individual field prospecting techniques, like soil sampling, drainage reconnaissance sampling and heavy mineral investigations.

72. Geochemical assaying is cheap and amounts to an average of 6d. per test per element. As each sample was tested for copper, nickel and lead by total extraction and for copper and zinc by cold extraction, geochemical testing cost about 2s. 9d. per sample.

73. Investigation of heavy mineral concentrates is rather expensive and averages about 30s. per concentrate. Expenditure for mineralogical investigation could be lowered by testing heavy mineral concentrates first by spectrographical methods for the presence of economic important elements. Subsequent mineralogical investigation could be restricted to concentrates containing such elements.

74. Overhead costs are relatively high. This is understandable as only large mining groups with the necessary technical know-how and financial resources are in a position to tackle mineral exploration on such a large scale.

Location Sketch Map

WESTERN RIFT CONCESSION

Figure I

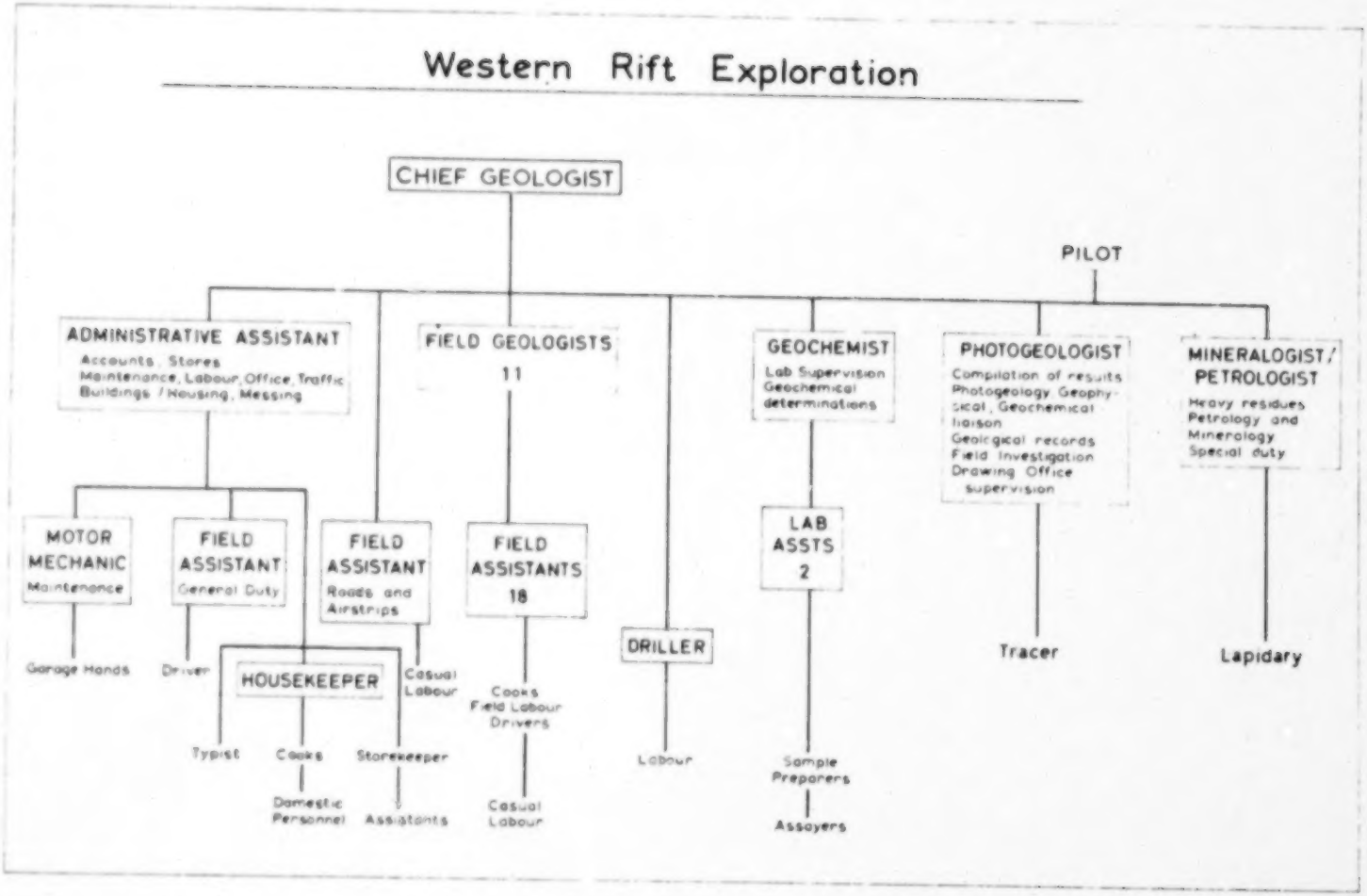
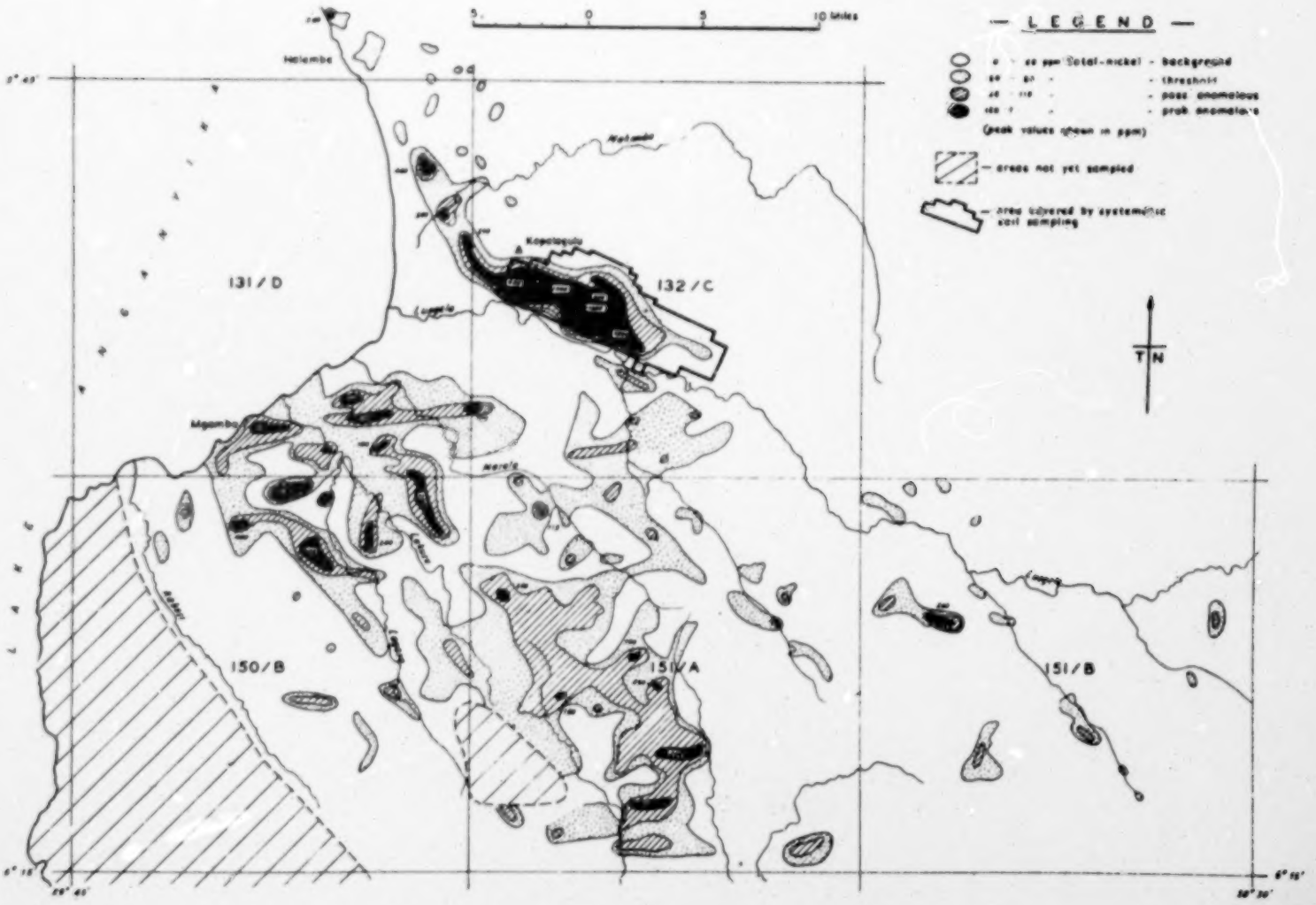

Western Rift Exploration
CHIEF GEOLOGIST
PILOT
ADMINISTRATIVE ASSISTANT
Accounts, Stores
Maintenance, Labour, Office, Traffic
Buildings / Housing, Messing
FIELD GEOLOGISTS
11
GEOCHEMIST
Lab Supervision
Geochemical determinations
PHOTOGEOLOGIST
Compilation of results
Photogeology Geophysical, Geochemical liaison
Geological records
Field Investigation
Drawing Office supervision
MINERALOGIST / PETROLOGIST
Heavy residues
Petrology and Mineralogy
Special duty
MOTOR MECHANIC
Maintenance
FIELD ASSISTANT
General Duty
FIELD ASSISTANT
Roads and Airstrips
FIELD ASSISTANTS
18
DRILLER
LAB ASSTS
2
Garage Hands
Driver
HOUSEKEEPER
Casual Labour
Cooks
Field Labour
Drivers
Tracer
Lapidary
Typist
Cooks
Storekeeper
Labour
Sample Preparers
Domestic Personnel
Assistants
Casual Labour
Assayers

Figure II

AREA KAPALAGULU

DRAINAGE RECONNAISSANCE - NICKEL ANOMALY PLOT



SEPTEMBER, 1960

Figure III